WORK-RELATED TRAINING OF ENGINEERS IN THE PRIVATE-FOR-PROFIT SECTOR, 1997

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EXECUTIVE SUMMARY

This report provides detailed information on the work-related training of engineers* in the private-for-profit sector, based on data from 1997 National Science Foundation (NSF) studies of college graduates. Two-thirds of engineers in the private-for-profit sector received work-related training in 1997. Engineers with doctorates, engineers in small companies, and engineers approaching retirement all reported training substantially less often than other engineers. However, most differences in the rates at which engineers received training were rather small. Engineers in the private-for-profit sector received training at rates similar to engineers working in other sectors, and to all other college graduates.

ENGINEERS IN THE PRIVATE-FOR-PROFIT SECTOR

- Firm size affected rates of training: only 50 percent of engineers in firms with fewer than 100 employees received training, while 74 percent of the engineers at firms with 5,000 or more employees received training.

- Training did not vary much among most of the age groups. Only the oldest group of engineers, age 60 to 75, received training substantially less frequently than other engineers; these older engineers reported training only about two-thirds as frequently as all engineers.

- Training varied little by main work activity. The only work activities with reports of training significantly above the 66 percent average were management related. In general, there was little variation in the incidence of training received by engineers engaged in even such disparate work activities as applied research, development, and sales/customer service.

- Training varied considerably by engineering specialty. Environmental, industrial, biomedical, and sales engineers received training most frequently, while aeronautical, nuclear, and marine engineers received training at rates that were below the average for all engineers.

- Female engineers across all age groups reported training slightly more frequently than their male counterparts. However, their advantage was primarily in occupational training and general professional training; females did not receive more management/supervisory training.

- Engineers employed in firms where the main business was manufacturing reported training at rates near the average for other private-for-profit sector engineers, as did engineers at firms specializing in information technology or computer services. While engineers in biotechnology firms reported training more frequently, in general, engineers reporting the most frequent training tended to be in older types of businesses such as transportation services, utilities, or communications.

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* Training includes work-related seminars, workshops, and other work-related training activities. Training excludes college and university courses and attendance at professional meetings, but would include a special training session conducted at a meeting or conference.

Engineers are defined to include all those college graduates working as engineers, including those who do not have engineering degrees. Also included are those with engineering degrees who are employed as technical managers.

- Nearly 10 percent of engineers in the private-for-profit sector reported that they did not have a "regular" job but had some kind of nontraditional relationship with their employer such as contract worker, temporary worker, or job sharing. Those engineers in nontraditional relationships reported training substantially less frequently than all engineers.

- Among engineers who received any work-related training in 1997, the average amount of time spent in training was 10 days. Only 5 percent of the days of training were paid for by the engineers themselves.

COMPARISON OF ENGINEERS IN THE PRIVATE-FOR-PROFIT SECTOR WITH OTHERS

- The approximately three-fourths of engineers employed in the private-for-profit sector received training at about the same rate as all engineers.

- Engineers in four-year college and universities reported training substantially less frequently. However, these engineers tended to take more college courses and attend more professional meetings as compared with those in the private-for-profit sector.

- Engineers in government received training more frequently than engineers in the private-for-profit sector. In the case of federal government employees, the proportion receiving training is about equal to the proportion in the largest private sector firms. However, state and local government employees received training even more frequently, 82 percent, with little variation by size of state/local government. At least part of the difference seems to be explained by the fact that state/local government engineers are concentrated in occupations such as civil and environmental engineering where the proportion of engineers receiving training is above average.

- While, in general, college-educated workers received training more frequently than those with less education, engineers received training at about the same rate as other college graduates.

INTRODUCTION

Work-related training is a common occurrence among engineers in the private sector. However, publications about the education and labor market for engineers tend to focus on formal education and provide little, if any, information about work-related training. This report focuses on work-related training[1] of engineers in the private-for-profit sector.

This paper uses data from the National Science Foundation (NSF) surveys of college graduates conducted in 1997 and earlier during the 1990s. These data[2] are excellent for answering such questions as: Who receives training? How does the incidence of training vary with firm size and with demographic characteristics of engineers? How does training vary with the type of work performed and the type of work arrangements with their employers? The NSF data also provide information on the reasons why engineers take training, the type of training received, and who pays for the training. Because the NSF data include all college graduates, it permits us to compare the training of engineers in the private sector with the training received by other engineers, and even with college graduates working in other occupations. Before examining these data on the training of engineers, however, a brief review of previous research on training is in order.

PREVIOUS RESEARCH ON TRAINING

Academic research on training has been heavily influenced by the ideas of Nobel laureate economist, Gary Becker. [Becker 1993] His book on human capital advanced the notion that education and training can be viewed not only as activities that impart knowledge but also as investments in human capital. The analogy to physical capital investments was found to be productive. He showed that employers and individuals may underinvest in human capital under certain circumstances—notably, in the case of individuals, because of imperfect capital markets, and in the case of firms, because much training is general in nature.

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[1] Training includes work-related seminars, workshops, and other work-related training activities. Training excludes college and university courses and attendance at professional meetings, but would include a special training session conducted at a meeting or conference. Four different kinds of training are identified: management training, training in one's occupational field, general professional training, and other work-related training. Management training was not defined more precisely; thus, it can include a range of training types from routine training frequently given to supervisors to expensive seminars offered by top business schools. General professional training includes, for example, public speaking, business writing.

[2] The National Science Foundation's data on engineers comes from its comprehensive system of information about the employment, educational, and demographic characteristics of scientists and engineers called SESTAT. The SESTAT system contains data from three NSF-sponsored demographic surveys, including 1997 responses from about 100,000 individuals. This paper focuses primarily on the subset with engineering jobs and also includes those with engineering degrees who reported a range of management jobs. For more information on SESTAT, see www.srsstats.sbe.nsf.gov.

Becker defined training as specific to a firm if the training would be of value only to people working in the same firm, and as general if the training could be used by workers at other firms if they left. Consider a common kind of training engaged in by engineers today—training in the use of new computer software such as modeling software used increasingly in engineering design. Engineers often take training courses, then practice on the job until they become proficient. Once the productivity is demonstrated, it becomes clear that the cost to the employer could be a good investment in human capital, i.e., it could help firms increase profits. However, to the extent that this software training could be used at another employer by engineers who leave (general training), the original firm would be unable to reap the full benefit of their investment. Thus, Becker showed that firms might underinvest especially in general training; and the firms would be more likely to underinvest the greater the likelihood of loosing their investment (i.e., the trained workers). Many other predictions have arisen from this theoretical framework as well, for example, that large firms would invest more in training and that investments may be greater in workers who have already demonstrated that they are efficient learners, that is, the more highly educated and able workers.

Much research was devoted to testing various hypotheses arising from human capital theory in the 1960s and 1970s, though most focused on the behavior of individuals. Only more recently has the data collection been improved enough to provide good information on the nature and extent of training opportunities provided by private businesses. One such improvement was a 1993 survey of employer-provided training conducted by the U.S. Department of Labor. Using data from this source, researchers showed that small firms (fewer than 50 employees) provided skill training much less often compared with large firms. (Frazis, et al. 1995)

While this finding is well established by other studies, the state of knowledge about firms providing training might be illustrated by the fact that there are several competing explanations as to why large firms provide much more training to their workers. (Frazis, et al. ; Barron, et al. 1987, Holtmann and Idson 1991) These explanations include the notion that large firms may be able to provide training at lower cost, to take more risk, or to accept a lower rate of return on their investments because of greater access to capital markets. Also, the findings have occasionally been inconsistent; for example, Knoke and Kalleberg (1994) failed to find a higher percentage of workers trained at larger firms. Perhaps most relevant to the training of engineers is the hypothesis that large firms have more physical capital and update that capital more frequently and thus have greater need to train and retrain their workers. This theory is based on the idea that human and physical capital are complementary and that the efficiency of human capital is enhanced by investment in human capital. (Frazis, et al.)

The incidence of training increases with years of education. College graduates receive several times more training than high school dropouts. (Bishop 1996) Workers who scored well on tests of verbal, mathematical, and technical competence when they were in school receive substantially more training than others. One study found that for people age 24 to 33, the impact of a standard deviation increase in all

subtests (verbal, math, etc.) increased the incidence of company training by about 36 percent, with schooling, experience, tenure, and firm size held constant. (Bishop)

The incidence of employer-provided skill training varies somewhat by industry: construction is relatively low, manufacturing near average, and finance, transportation, communication, and public utilities are all above average. Also, workers who are expected to have a long future tenure are predicted to receive more training. This can't be observed directly, but researchers have shown that several practices of firms associated with lower turnover are also associated with higher incidence of training. Notably, providing a large number of benefits helps to establish a long-term commitment between the employer and employee and is strongly associated with the provision of training. (Fraxis, et al.)

Other studies have confirmed that the percentage of workers given training was highest in establishments with large investments in physical capital, or in those establishments that had adopted new forms of work organization, especially in the manufacturing sector. Researchers concluded, "employer-provided training complements rather than substitutes for investments in physical capital and education." (Lynch and Black 1998)

Job characteristics also impact the likelihood and amount of training received. Full-time, regular (non-temporary) jobs, cognitively complex jobs (e.g., professional, technical, and managerial jobs), and high value-added jobs where the individual has great responsibility all tend to be characterized by greater training. (Bishop)

One study focused specifically on training of engineers employed in the private sector. (Dauffenbach and Finn, 1985) It used data from NSF's 1982 National Survey of Natural and Social Scientists and Engineers to examine the incidence of training for engineers working as engineers, excluding those whose primary work activity was management. Multivariate statistical analysis was used to isolate the effect of certain variables with the following results. Engineers were found to be less likely to receive employer-provided training if they changed employers, more likely if they did not change employers but changed job duties or occupation. By education category, doctorates were least likely to receive training; those with a bachelor's that was not an engineering degree, the most likely. Engineers' incidence of training declined with years of professional work experience, and those reporting primary work activities in R&D received training less frequently than others. The same study examined the impact of training on engineers' salaries. Controlling for other variables that could be measured, the authors estimated that those engineers who had received training during the previous year earned modestly higher salaries, with the impact of training being about one-third as great as the impact of having a master's degree in engineering instead of a bachelor's.

Another study is of interest because it focused on training received by scientists. (Finn 1981) This study found that training enhanced earnings and that women scientists got the same return from employer-

provided training as men. However, women scientists and engineers received less training prior to 1972. Data showed no gender difference in training received in the late 1970s, however, indicating that one cause of an earnings gap between men and women scientists was probably diminishing.

In each instance where research has shown differences in the incidence of training, e.g., educated workers receive more training, there is an interesting unanswered question. Is this because employers offer training less frequently to some workers or because these workers respond differently to the opportunities for training? A recent paper by Leuven and Oosterbeek (1999) tries to answer this question. Examining data from four industrialized countries, they conclude that the answer is not a simple one, but in the United States "firms are more likely to face workers who are unwilling to take training" than are workers to face firms unwilling to provide training. (Leuven and Oosterbeek) While their research is not definitive, it offers an interesting approach for trying to understand why observed differences in training exist.

Little of the previous research reviewed for this paper deals specifically with the training of engineers, although it suggests that engineers and other professional workers are more likely to have it provided by their employer than are workers with less education. The research also suggests that training is becoming more important because firms are increasing their use of highly educated workers and capital and because worker training is complementary to these inputs.

DATA USED FOR THIS STUDY

The primary source of data for the sections that follow is the NSF SESTAT system. The 1997 data in SESTAT is based on surveys of college graduates conducted in the spring and summer of that year. For this study, we examined data specifically for engineers which included the following: work-related training received during the preceding 12 months; the kind of training received: management or supervisory training, training in one's occupational field, or general professional training; reasons for taking the training; number of days of training received and the number the employee paid for.

Definition of Engineers

All college graduates with engineering jobs are counted as engineers, regardless of their field of study in college. This narrow definition would exclude engineering managers, however. Therefore, this study counts within the broad definition of engineers those who meet the following operational definition of technical managers. Technical managers are defined to include persons who identify their occupation as management-related, whose last degree was an engineering degree, and who stated that *either* their work was somewhat or closely related to their last degree, *or* the work required at least a baccalaureate in the natural sciences or engineering.

SESTAT also includes data on engineers' work, education, and demographic characteristics which, in this review of training data that follows, we frequently cross-tabulate with training questions in an effort to understand why and under what circumstances training is most frequently undertaken.

PRIVATE-FOR-PROFIT SECTOR ENGINEERS RECEIVING TRAINING

Overall, 66 percent of engineers in 1997 reported having received some kind of work-related training in the preceding year. (Table 1) While not every engineer received training every year, for most subsets of the engineers, the proportion receiving training during the preceding year was not far from this 66 percent average. For example, the incidence of training for engineers with a master's as their highest degree was virtually the same as for those whose highest degree was a bachelor's, 67 versus 66 percent. The doctorates were somewhat lower, at 60 percent. The only category where training was received by substantially less than the 66 percent average was for engineers age 60 to 75.

Table 1. Private-for-Profit Sector Engineers Receiving Training, by Age and Level of Highest Degree, 1997
(by percent)

Age	Bachelor's	Master's	Doctorate	Total, All Degrees
29 & under	70	66	75	69
30 to 39	68	69	69	69
40 to 49	67	70	59	67
50 to 59	65	62	54	63
60 to 75	43	48	39	44
Total	**66**	**67**	**60**	**66**

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

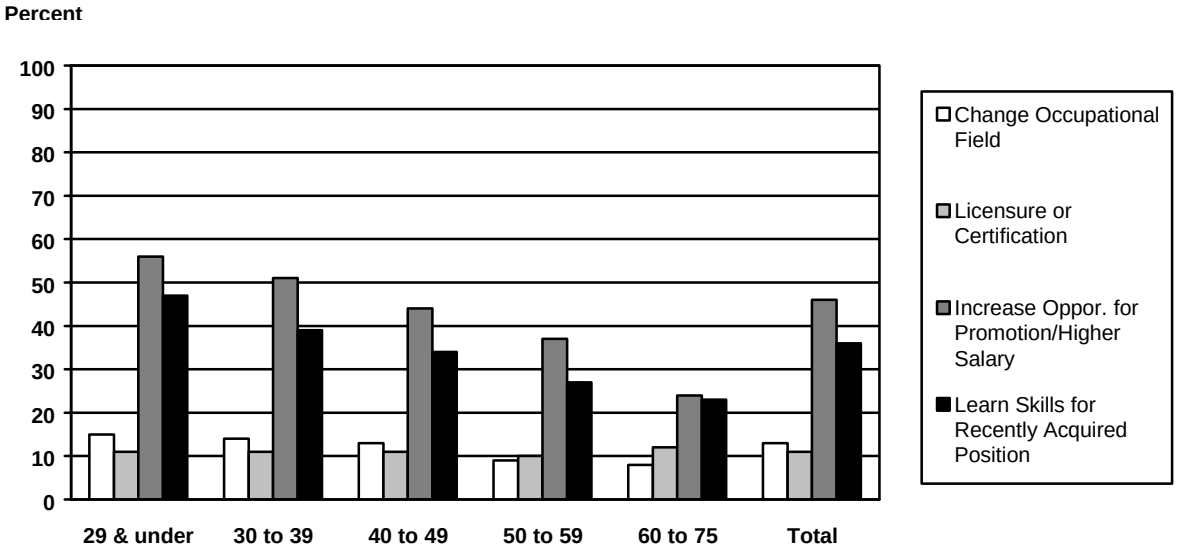
Table 1 shows relatively little decline in training among engineers up through age 59. This is remarkable when considering that training is often viewed as an investment that will pay returns over a number of years. If the payoff from the training—enhanced productivity—unfolds over many years to come, one would expect that both individuals and employers might be inclined to invest more in training as well as education of younger workers. The fact that training occurs throughout an engineer's career may reflect the fact that much training is specific to current laws, regulations, and practice (as opposed to education, which focuses more on general principles and knowledge).

REASONS FOR TRAINING

As Figure 1 shows, engineers engaging in training did so for a number of reasons, often more than one. About half were interested in increasing their opportunities for a promotion, and more than one-third wanted to learn new skills for a recently acquired position. As promotions occur more frequently during the first part of an engineer's career, these reasons for taking training drop significantly with age. Relatively small proportions of the engineers receiving training indicated that their reason was to change occupational field or for licensure or certification. Licensure/certification was not frequently cited as a reason for training because so many engineers did not seek a license or certification. However, it is

important for those who do obtain and maintain these credentials. While other reasons given for receiving training in Figure 1 declined with age, for licensure/certification there was no such decline. Engineers with licenses or certification often have no choice but to take training courses to maintain their credentials.

Figure 1. Private-for-Profit Sector Engineers Receiving Training, by Age and Reason for Participation, 1997



Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

TYPE OF TRAINING

Table 2 shows the distribution of private-for-profit sector engineers who attended training, by type of training received and by degree level and age. Overall, 83 percent of those with training in 1997 identified it as occupational training (that is, related to the content of their jobs), while 37 percent reported management/supervisory training and 25 percent reported general professional training. These percentages sum to more than 100 because many engineers received more than one type of training. Age played a role in determining the type of training as the proportion receiving management training was below average for the youngest age group. In contrast, engineers under age 30 showed above-average levels of occupational training and general professional training.

Table 2. Private-for-Profit Sector Engineers Receiving Training, by Age, Highest Degree, and Type, 1997
(by percent)

Age	Bachelor's	Master's	Doctorate	All Degree Levels
Management/supervisory training				
29 & under	30	25	24	29
30 to 39	34	38	33	35
40 to 49	43	35	38	40
50 to 59	39	42	40	40
60 to 75	32	38	30	34
Total	37	36	36	37
Occupational training				
29 & under	92	91	93	91
30 to 39	86	87	79	86
40 to 49	80	80	80	80
50 to 59	77	78	71	78
60 to 75	85	68	76	80
Total	84	83	77	83
General professional training[1]				
29 & under	28	28	11	28
30 to 39	24	26	27	25
40 to 49	25	26	21	25
50 to 59	29	21	25	27
60 to 75	25	10	24	21
Total	26	25	24	25

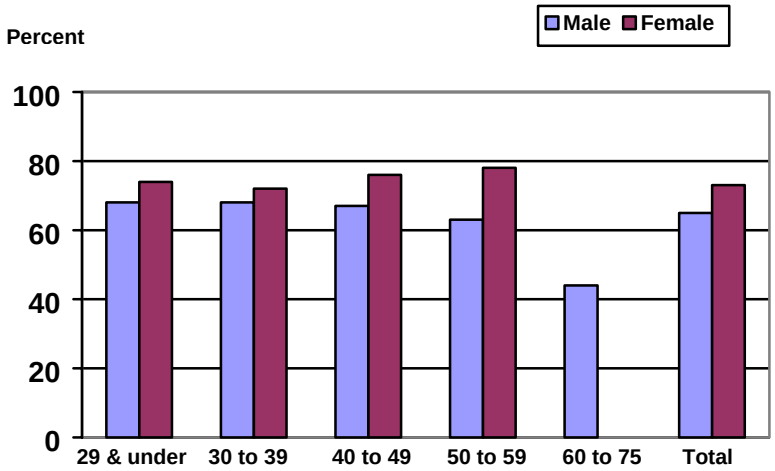
NOTES: Training types total more than 100% because engineers were permitted to report different kinds of training in the same year.
[1]General professional training was e.g., public speaking, business writing.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

GENDER DIFFERENCES IN TRAINING

Female engineers, regardless of age, took training somewhat more frequently than did their male colleagues. (Figure 2) A more detailed analysis of gender differences in training takes into account the type of training reported as shown in Table 3. Female engineers were slightly more likely than their male counterparts to report general professional training and training in their occupational field. However, female engineers did not report more management or supervisory training. Most of the male/female differences in management/supervisory training shown in Table 3 were too small to be statistically significant, but the relatively small number of female engineers age 50-59 received different levels of the same types of training compared with male cohorts: less management training and more occupational training.

Figure 2. Private-for-Profit Sector Engineers Receiving Training, by Age and Gender, 1997



NOTE: Female 60 to 75 was suppressed due to small number of cases.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Table 3. Private-for-Profit Sector Engineers Receiving Training, by Age, Type of Training, and Gender, 1997
(by percent)

	Management/ Supervisory Training		Occupational Training		General Professional Training[1]		Total, Any Kind of Training	
Age	Male	Female	Male	Female	Male	Female	Male	Female
29 & under	20	19	62	68	17	27	68	74
30 to 39	24	24	59	62	16	22	68	72
40 to 49	27	24	53	64	17	23	67	76
50 to 59	26	13	48	70	17	18	63	78
60 to 75	15	s	35	s	9	s	44	s
Total	**24**	**22**	**54**	**64**	**16**	**23**	**65**	**73**

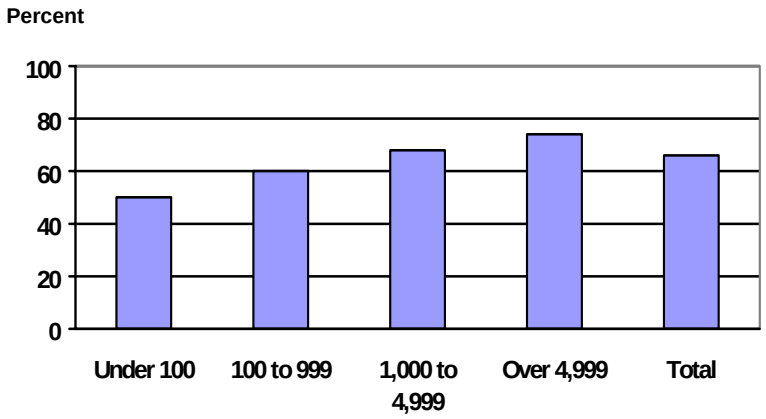
NOTES: Training types total more than 100% because engineers were permitted to report different kinds of training in the same year.
[1]General professional training was, e.g., public speaking, business writing.
s = suppressed due to small number of cases.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

SIZE OF EMPLOYER

Figure 3 shows a clear relationship between the incidence of training and size of employer, that is, the smaller the employer, the lower the likelihood of training. Half of the engineers employed at firms with fewer than 100 employees received training in 1997 compared with about three-fourths in firms with 5,000 or more employees.

Figure 3. Private-for-Profit Sector Engineers Receiving Training, by Size of Employer, 1997



Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

ENGINEERING SPECIALTY

The incidence of training varies considerably by engineering specialty. (Table 4) Nuclear engineers had the lowest incidence at 55 percent, while environmental engineers had the highest at 77 percent.

Not surprisingly, those in technical management jobs reported management training more often than others, but those with mining/geological positions also reported management training at above average rates. (Table 6) Computer software engineers and sales engineers reported management training least often. The biomedical engineers, computer engineers, and sales engineers reported occupational training more often than others. Overall, 83 percent of engineers with training reported receiving training in their occupational field.

The reasons for taking training vary somewhat by engineering specialty. The principal reasons for attending management or supervisory training are given in Table 5. The most commonly cited reason, to gain further knowledge or skills in the occupational field, is a bit difficult to interpret. This reason was given by 55 percent of all engineers, compared with only 17 percent who indicated that the training was required or expected by their employer. Perhaps this means that management and supervisory training is

overwhelmingly a voluntary activity, not something that engineers do primarily because their employers want them to.

Table 4. Private-for-Profit Sector Engineers, by Specialty and Type of Training, 1997
(by percent)

Engineering Specialty	Percentage Reporting Training	Training Type for Those Reporting Training		
		Management/ Supervisory	Occupational Training	General Professional[1]
Aeronautical/aerospace/astronautical engineers	58	41	77	25
Biomedical/bioengineers	72	28	90	38
Chemical engineers	69	38	80	32
Civil engineers	64	31	87	20
Computer hardware engineers	66	29	90	23
Computer software engineers	68	23	92	19
Electrical/electronic engineers	64	31	87	24
Environmental engineers	77	31	90	24
Industrial engineers	72	41	79	25
Marine engineers	53	s	s	s
Materials/metallurgical engineers	62	38	77	26
Mechanical engineers	66	37	84	28
Mining/geological engineers	66	67	60	22
Nuclear engineers	55	57	84	44
Petroleum engineers	61	37	93	22
Postsecondary engineering faculty	s	s	s	s
Sales engineers	71	28	87	36
Technical managers[2]	64	66	65	30
Other engineers	63	38	81	32
Estimated total, all specialties	**66**	**37**	**83**	**25**

NOTES: Training types total more than 100% because engineers were permitted to report different kinds of training in the same year.
[1]General professional training was, e.g., public speaking, business writing.
[2]Includes persons who identify their job as management-related, whose last degree was an engineering degree and who stated that *either* their work was closely or somewhat related to the last degree, *or* the work required at least a baccalaureate in the natural sciences or engineering.
s = suppressed due to small number of cases.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Table 5 shows that only 2 percent of engineers said they took management or supervisory training primarily to change their occupational field. A higher number, 13 percent, of engineers reported the primary reason for their management or supervisory training was to increase opportunities for promotion or a raise. One might conclude that most engineers viewed management and/or supervision as integral to their work, whether or not they reported management rather than one of the engineering specialties.

Table 5. Private-for-Profit Sector Engineers Receiving *Management/Supervisory* Training, by Specialty and Primary Reason for Training, 1997
(by percent)

Engineering Specialty	Primary Reason for Attending Management/Supervisory Training						
	To Change Occupational Field	For Licensure or Certification	To Gain Further Skills in Occupation	To Increase Opportunities for Promotion/ Higher Salary	To Learn Skills for Recently Acquired Position	Required or Expected by Employer	Other
Aeronautical/aerospace/astro. engineers	s	0	35	22	7	30	s
Biomedical/bioengineers	0	0	43	s	s	s	0
Chemical engineers	s	s	51	13	8	23	s
Civil engineers	s	8	55	14	s	17	s
Computer hardware engineers	s	0	57	s	12	s	s
Computer software engineers	s	s	63	13	11	10	s
Electrical/electronic engineers	3	s	55	12	9	19	s
Environmental engineers	s	15	54	12	s	12	0
Industrial engineers	s	s	53	16	12	16	s
Marine engineers	0	s	s	s	0	0	0
Materials/metallurgical engineers	s	s	55	16	11	16	s
Mechanical engineers	2	s	52	15	9	19	s
Mining/geological engineers	0	s	s	s	0	s	0
Nuclear engineers	0	s	s	s	s	s	s
Petroleum engineers	s	s	55	s	s	s	s
Postsecondary engineering faculty	0	0	0	0	0	0	0
Sales engineers	s	0	39	21	13	25	s
Technical managers[1]	2	1	61	10	10	13	3
Other engineers	s	s	45	s	17	20	s
Estimated total, all specialties	**2**	**2**	**55**	**13**	**9**	**17**	**2**

NOTES: [1]Includes persons who identify their occupation as management-related, whose last degree was an engineering degree and who stated that *either* their work was closely or somewhat related to the last degree, *or* the work required at least a baccalaureate in the natural sciences or engineering.
s = suppressed due to small number of cases.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

The primary reasons given for occupational training are reported in Table 6. Gaining further skills or knowledge in the occupational field was cited by 66 percent of all engineers reporting training. Other reasons were cited frequently by those in aeronautical/aerospace/astronautical engineering and chemical engineering, for example, employer requirements or expectations. Biomedical/bioengineers cited to learn skills for a new job most frequently, while environmental and civil engineers were most likely to cite licensure or certification as a motive for occupational training.

Table 6. Private-for-Profit Sector Engineers Receiving Training in *Occupational Field*, by Specialty and Primary Reason for Training, 1997
(by percent)

Engineering Specialty	Primary Reason for Attending Occupational Training						
	To Change Occupational Field	For Licensure or Certification	To Gain Further Skills in Occupation	To Increase Opportunities for Promotion/ Higher Salary	To Learn Skills for Recently Acquired Position	Required or Expected by Employer	Other
Aeronautical/aerospace/astro. engineers	s	s	58	10	10	16	s
Biomedical/bioengineers	0	0	57	s	24	s	s
Chemical engineers	3	s	64	6	9	16	1
Civil engineers	1	10	67	7	3	10	s
Computer hardware engineers	s	s	74	5	13	5	s
Computer software engineers	1	1	69	7	10	10	1
Electrical/electronic engineers	3	3	69	7	7	11	1
Environmental engineers	3	14	61	6	6	8	s
Industrial engineers	s	s	65	8	11	11	s
Marine engineers	0	s	53	s	s	s	0
Materials/metallurgical engineers	s	s	68	7	11	7	3
Mechanical engineers	2	3	66	8	9	12	1
Mining/geological engineers	s	s	81	s	s	s	0
Nuclear engineers	s	s	27	s	s	s	s
Petroleum engineers	s	s	69	s	12	s	s
Postsecondary engineering faculty	0	0	0	0	s	0	0
Sales engineers	s	s	57	12	9	18	s
Technical managers[1]	2	3	67	6	10	11	1
Other engineers	s	s	70	6	6	15	s
Estimated total, all specialties	**2**	**3**	**66**	**7**	**9**	**11**	**1**

NOTES: [1]Includes persons who identify their occupation as management-related, whose last degree was an engineering degree and who stated that *either* their work was closely or somewhat related to the last degree, *or* the work required at least a baccalaureate in the natural sciences or engineering.
s = suppressed due to small number of cases.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Tables 5 and 6 indicate that in most engineering specialties a small proportion attended training activities to learn skills or knowledge for a recently acquired position. For up to 24 percent this was a primary reason, regardless of engineering occupation. Clearly learning skills and knowledge for a new job is an important motivation for training. However, since only a minority were in a new job, it is not surprising that training taken by most engineers did not relate to needs associated with a new position. Environmental and civil engineers were most likely to take training as a part of requirements for licensure or certification. This is not surprising given the rate of licensure among them and the importance of health and safety in these fields.

OTHER MODES OF LEARNING

Engineers were also asked if they had taken college courses since their most recent degree, and whether they had attended professional meetings or conferences as distinct from their short-term training. Only 13 percent of engineers employed in the private-for-profit sector took college courses during 1995-1997. Attendance at professional meetings or conferences was a means of keeping up that was employed more

frequently. Nearly half (48%) of engineers employed in the private-for-profit sector attended such meetings in 1995-1997. However, these other ways of keeping up did not seem to serve as substitutes for training. Engineers who took college courses were just as likely to participate in a training program as engineers who did not. Engineers who attended professional meetings were more likely than other engineers to participate in training, 77 percent versus 56 percent.

JOB CHANGES

Much of the training received by engineers in the private-for-profit sector is related to the specific duties of their current job. A sales engineer does not receive the same training as an engineer whose main work activity is design, and supervisory or management training is more common after a person is promoted to a position entailing more responsibilities in these areas. Thus, it might be expected that people experiencing job change would report training most frequently. Table 7, however, indicates a different pattern. Engineers who changed jobs but stayed with the same employer reported training at a higher rate than other engineers, 76 percent. In contrast, engineers who changed both jobs and employers reported training at a slightly below-average rate, 62 percent.

Table 7. Private-for-Profit Sector Engineers Receiving Training, by Comparison of 1995 Versus 1997 Jobs and Occupation Group, 1997
(by percent)

	Yes, took training		
Job Comparison, 4/95 vs. 4/97	Engineer	Technical Manager	Total
Same employer/same job	65	63	64
Same employer/different job	77	71	76
Different employer/same job	69	58	68
Different employer/different job	62	64	62
Total employed in 1995 and 1997	**66**	**64**	**64**

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Table 8 reports on the training of those who changed jobs by reason given for the change. Those in the private-for-profit sector who reported retirement as a reason for changing jobs reported the lowest incidence of training at 46 percent. Other reasons cited for changing jobs that are associated with below-average training rates were “laid off or job terminated.”

Table 8. Private-for-Profit Sector Engineers Receiving Training, by Reason for Changing Employer or Job and Occupation Group, 1997
(by percent)

Reason for Changing Employer or Job, 4/95 vs. 4/97	Yes, took training		
	Engineer	Technical Manager	Total
Pay, promotion opportunities	71	71	71
Working conditions	69	56	68
Job location	69	61	68
Change in career or professional interests	73	66	72
Family-related reasons	66	63	66
School-related reasons	65	s	66
Laid off or job terminated	63	51	61
Retired	42	s	46
Other	71	s	67
Total employed in 1995 and 1997	**66**	**64**	**66**

NOTE: s = suppressed due to small number of cases.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

As is shown later in this paper, nearly all work-related training is paid for by employers. Thus, the lower incidence of training reported by those previously laid off is probably primarily the result of the kind of jobs they subsequently obtained. Whether this group was also less likely to take advantage of training opportunities is something these data cannot answer.

TRAINING AND EXTENT OF JOB/DEGREE MATCH

So far there has been little evidence that training is used as a substitute for education. That is, baccalaureate engineers reported training at about the same rate as those with a master's degree. Is training, however, used to upgrade skills of engineers who end up in jobs that do not match well with their education? Table 9 shows that the percentage of engineers reporting training during the previous year was virtually the same for those whose highest degree was engineering as it was for others.

Table 9. Private-for-Profit Sector Engineers Receiving Training, by Field of Study for Highest Degree and Degree Level, 1997
(by percent)

Degree Field	Highest degree level:[1] Bachelor's	Master's	Doctorate	Total, All Degree Levels
Highest degree in engineering	65	66	61	65
Degree in engineering, but not the highest degree	na	66	43	64
No degree in engineering	68	70	60	68
Total	**66**	**67**	**60**	**66**

NOTE: [1]Highest degree is used in this table, which is the same as most recent degree 99.6% of the time.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

It may be that some of the engineers were in jobs where, in spite of their lack of an engineering degree, they had no more need of training than did those with engineering degrees. However, given the high standing of engineering education,[3] one might hypothesize that those without engineering degrees, on average, would need more training than those with engineering degrees, at least when doing engineering work. If so, however, they did not receive it.

Table 10 provides more detailed information on training for persons whose work was not closely related to their degree fields. The top section of Table 10 repeats the data from Table 9, and below that the data are further disaggregated by how related respondents' work was to their jobs.

Overall, Table 10 shows that the incidence of training does NOT vary significantly with the match between their work as engineers and field(s) of their degree. It is true that there was a greater reported incidence of training among doctorates reporting their job was not closely related to their highest degree. However, the vast majority of engineers had as their highest degree a bachelor's or master's degree. For these engineers, there was a lower tendency to receive training if their job was not related to their highest degree field(s).

[3] Studies of salaries earned by persons with different college degrees attest to the high regard employers place on engineering degrees. Not only do persons with engineering degrees tend to be paid more than others when they work as engineers, they also earn premium salaries when working in non-engineering jobs. [Dauffenbach and Finn 1990]

Table 10. Private-for-Profit Sector Engineers Receiving Training, by Field of Study for Highest Degree, Job/Degree Match, and Degree Level, 1997
(by percent)

Job/Degree Match and Degree Field	Highest degree level:[1] Bachelor's	Master's	Doctorate	Total, All Degree Levels
Overall:				
Highest degree in engineering	65	66	61	65
Degree in engineering, but not the highest degree	na	66	43	64
No degree in engineering	68	70	60	68
Total	66	67	60	66
Work closely related to highest degree field:				
Highest degree in engineering	65	66	62	65
Degree in engineering, but not the highest degree	na	68	45	66
No degree in engineering	69	71	63	69
Total	66	67	61	66
Work somewhat related to highest degree field:				
Highest degree in engineering	67	65	58	66
Degree in engineering, but not the highest degree	na	69	54	67
No degree in engineering	70	71	61	70
Total	68	67	59	67
Work not related to highest degree field:				
Highest degree in engineering	60	61	64	60
Degree in engineering, but not the highest degree	na	48	20	44
No degree in engineering	61	64	57	61
Total	61	59	57	60

NOTE: [1]Highest degree is used in this table, which is the same as most recent degree 99.6% of the time.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Table 11 repeats the data of Table 10, but disaggregates the group without engineering degrees into those with business degrees versus all others. A master's in business is a fairly common degree among engineers and engineering managers. The group of engineers with MBAs or equivalent degrees may be presumed to have more knowledge of management and supervisory issues than all other engineers. Does this mean they receive less management or supervisor training? Not so, according to Table 11, those with a master's in business received this type of training more frequently.

Table 11. Private-for-Profit Sector Engineers Receiving *Management/Supervisory* Training, by Field of Study for Highest Degree, Job/Degree Match, and Degree Level, 1997
(by percent)

Job/Degree Match and Degree Field	Highest degree level:[1] Bachelor's	Master's	Doctorate	Total, All Degree Levels
Overall:				
Engineering	26	24	23	25
Business	21	33	s	31
Other	19	20	17	19
Total	24	24	21	24
Work closely related to highest degree field:				
Engineering	24	23	22	24
Business	s	45	s	41
Other	18	20	17	18
Total	22	25	21	23
Work somewhat related to highest degree field:				
Engineering	29	25	23	28
Business	s	26	s	25
Other	22	22	19	22
Total	28	25	22	27
Work not related to highest degree field:				
Engineering	23	20	27	22
Business	s	22	s	26
Other	20	15	16	18
Total	22	19	21	21

NOTES: [1]Highest degree is used in this table, which is the same as most recent degree 99.6% of the time.
s = suppressed due to small number of cases.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Table 12 is a repeat of Table 11 but is restricted to the subset of engineers who supervised the work of others (about half of all engineers in the private-for-profit sector). Overall, the proportion with management/supervisory training went up from 24 to 35 percent as we examine the subset with supervisory responsibilities. There was little difference by degree level. The engineers with MBA degrees were the ones who most often reported management/supervisory training, which is essentially the same finding as Table 11 and strengthens our conclusion that training and education were complementary. That is, the high proportion of MBA-degreed engineers reporting management/supervisory training did not result from the job assignments of these engineers. Even when compared only to other engineers with supervisory responsibilities, the MBA-degreed engineers were the most likely to receive management/supervisory training.

Table 12. Private-for-Profit Sector Engineers Who Supervise the Work of Others Receiving *Management/Supervisory* Training, by Field of Study for Highest Degree, Job/Degree Match, and Degree Level, 1997
(by percent)

Job/Degree Match and Degree Field	Highest degree level:[1] Bachelor's	Master's	Doctorate	Total, All Degree Levels
Overall:				
Engineering	36	34	33	36
Business	41	42	0	42
Other	31	31	32	31
Total	35	35	32	35
Work closely related to highest degree field:				
Engineering	34	34	32	34
Business	s	53	0	52
Other	28	33	32	29
Total	33	36	32	34
Work somewhat related to highest degree field:				
Engineering	40	35	33	39
Business	s	33	0	37
Other	32	30	31	33
Total	39	34	32	37
Work not related to highest degree field:				
Engineering	37	27	38	34
Business	s	s	0	s
Other	38	s	32	34
Total	37	24	36	33

NOTES: [1]Highest degree is used in this table, which is the same as most recent degree 99.6% of the time.
s = suppressed due to small number of cases.

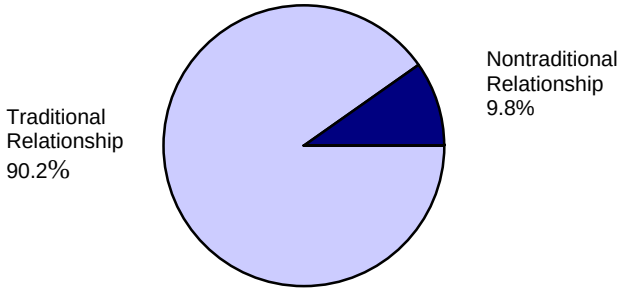
Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

WORK RELATIONSHIP WITH EMPLOYER

During the 1990s, there was publicity about downsizing by major employers and the growth of nontraditional[4] working relationships. Some of these nontraditional relationships, such as job-sharing and working from home, have developed primarily to accommodate workers needs. Other nontraditional working relationships are often motivated more by the reluctance of large employers to staff up fully with full-time, "regular" employees. They have found that they can respond to changing demand more readily if part of their work force consists of temporary or seasonal workers. In addition, firms sometimes contract out whole work functions (e.g., computer or engineering services) that employ significant numbers of engineers. Thus, an engineer comes to work every day at Company X, but he or she is actually an employee of Company Y. Figure 4 shows that about 10 percent of all engineers employed in the private-for-profit sector in 1997 indicated that they had some type of nontraditional work relationship with their employer. Figure 5 shows that the percentage of engineers reporting training was substantially lower within the subset who have nontraditional work relationships.

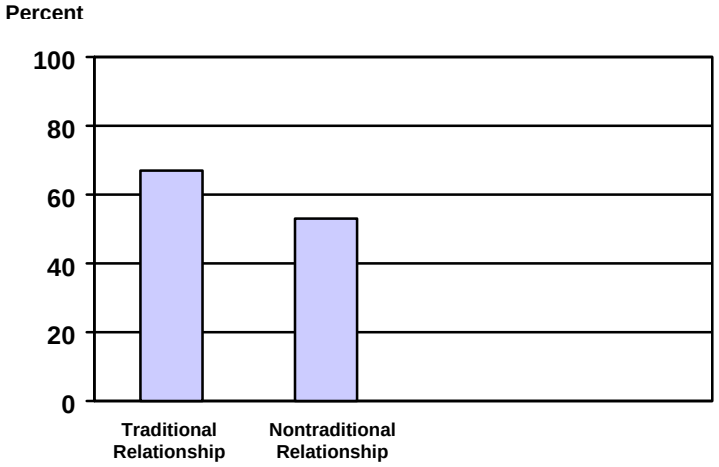
[4] Nontraditional relationship is defined to include any of the following: engineers whose principal employer contracted out their services to other organizations; engineers working on an as-needed, seasonal,

Figure 4. Private-for-Profit Sector Engineers in Traditional Versus Nontraditional Work Relationships with Their Employers, 1997



Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Figure 5. Private-for-Profit Sector Engineers Receiving Training, by Type of Work Relationship, 1997



Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

While 53 percent of engineers with nontraditional relationships reported training in the previous year, this varied depending on the type of nontraditional relationship. Table 13 indicates that about 93,000 of the 145,000 engineers with nontraditional working relationships were what might be called contract workers. These engineers reported training at the 60 percent rate, which is below the national average rate of 66 percent, but the difference is not great and is typical of engineers in smaller firms. About a third of the engineers with nontraditional working relationships were not contract workers in 1997 but were temporary, seasonal, working from home, or nontraditional in some other respect. These engineers make up only

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or short-term basis; engineers engaging in job sharing or working from home for at least 50 percent of the time; and any other relationship considered by the engineer to be an alternative or temporary relationship.

about 3 percent of all engineers in the private-for-profit sector. Except for a small number who reported some "other" but unspecified nontraditional relationship and who reported a training rate of 79 percent, less than half of the rest engaged in training of any kind.

Table 13. Private-for-Profit Sector Engineers Receiving Training, by Presence of Alternative/Temporary Work Relationships, 1997

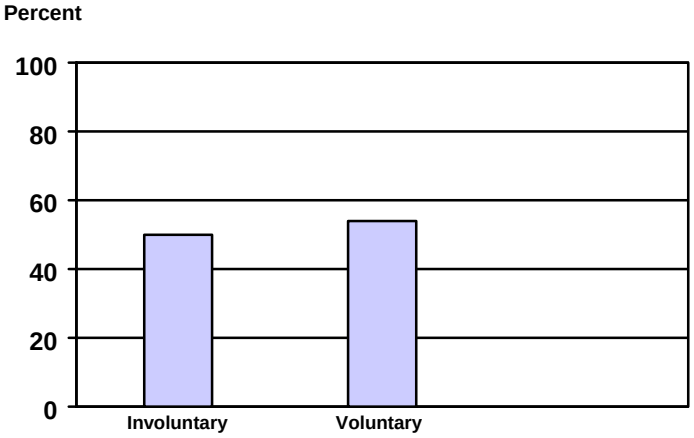
Type of work relationship with employer	Engineers Employed	Percentage Reporting Training
Traditional relationship	1,334,900	67
Alternative/temporary relationship:		
Principal employer contracted out engineer's services to other organizations (not including temporary help or employment agencies)	92,700	60
Working through a temporary help or employment agency	15,500	40
Working on an "as needed," "seasonal," or "short-term" basis	33,100	38
Job sharing	3,600	37
Working from home for 50 percent or more of work time	34,700	49
Other alternative or temporary relationship	4,600	79
Total, any alternative/temporary relationship	145,400	53

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Few engineers in nontraditional work relationships were in them involuntarily.[5] Only 16 percent of the engineers with alternative or temporary working relationships preferred a traditional employment relationship. Figure 6 shows similar levels of training regardless of whether engineers were in a nontraditional setting voluntarily or involuntarily.

[5] The arrangement was defined as involuntary if they indicated their preference was for a permanent job and also, if the reason they were in a temporary job or an alternative working relationship was that (a) their employer changed their status to temporary; (b) it was the only kind of work they could find; or (c) they took their current job to gain experience that might lead to a permanent job.

Figure 6. Private-for-Profit Sector Engineers Reporting Training, by Nature of the Alternative/Temporary Work Relationship, 1997



Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

A variety of conclusions might be drawn from the data discussed above. One is that not many engineers are employed in these nontraditional ways, and that most who are seem to have chosen these arrangements voluntarily. The incidence of training was lowest for those who had what might be called weak job attachment, i.e, they worked at a temporary help agency or on a short-term or "as-needed" basis. This is entirely consistent with previous research suggesting that employer-provided training will be less when the employer can expect fewer years of future employment during which to recover the investment. (Frazis, et al.) If those with the least training were those who wanted regular jobs but couldn't find them, this might be viewed as a significant training deficiency. However, there was no significant difference in training incidence between those who had these arrangements involuntarily compared with the larger number who preferred them to regular employment. Simply stated, engineers in temporary/alternative work relationships took less training in 1996, but the vast majority weren't forced into these arrangements; they must think there are advantages that offset the lower incidence of training. The nature of their jobs may, in fact, rely exclusively on what they already know and can do, yet may not have growth or promotion potential. This may be just fine as far as they are concerned.

EMPLOYER'S MAIN BUSINESS

The frequency with which engineers received training varies by industry, or by the employer's main business as it is called in Table 14. More than a third of these private sector engineers were employed in manufacturing establishments, and they took training about as frequently as all private sector engineers. Among other large employer types, engineers in information technology or computer services received training somewhat less frequently as compared with engineers in the transportation services, utilities, and communications. It is not known precisely why these differences exist. One possibility is that the engineers in transportation, utilities and communications deal with highly regulated environments, whereas

fewer of the engineers in information technology and computer services need to keep abreast of or enforce government regulations. This reasoning also fits with why environmental and civil engineers had big training rates.

Table 14. Private-for-Profit Sector Engineers Receiving Training, by Employer's Main Business, 1997

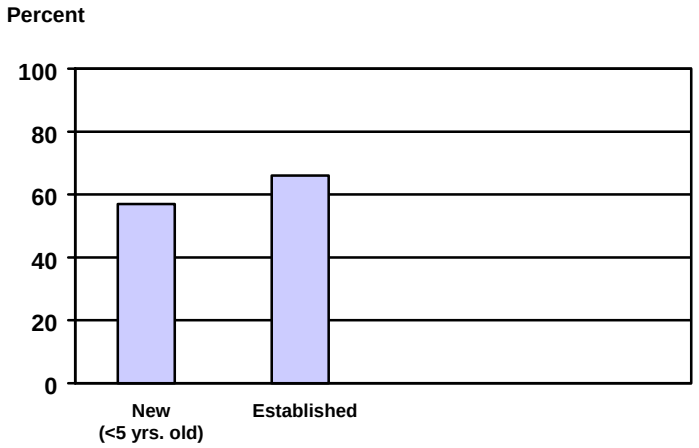
Employer's Main Business	Engineers Employed	Percent with Training
Agriculture, forestry, fishing	2,500	48
Biotechnology	13,000	72
Construction, mining	92,000	62
Finance, insurance, or real estate services	21,200	69
Health services	6,600	59
Information technology or computer services	277,000	64
All other services	69,400	59
Manufacturing	562,600	68
Research	67,400	63
Transportation services, utilities, or communications	123,700	76
Wholesale or retail trade	16,900	70
Other	228,000	62
Total	**1,480,300**	**66**

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

NEW VERSUS ESTABLISHED EMPLOYERS

Only about 6 percent of engineers employed in the private-for-profit sector worked for companies that had been in existence less than 5 years. These engineers reported training less frequently than did others as indicated in Figure 7. However, most new companies are small firms, and the frequency of training at these new companies is close to that reported earlier for smaller companies.

Figure 7. Private-for-Profit Sector Engineers Receiving Training, by New Versus Established Companies, 1997



Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

MAIN WORK ACTIVITY[6]

Table 15 shows how the incidence of training varied with work activities. Training occurred most frequently among engineers whose main work activities were management or management related: employee relations (72 percent), production, operations, maintenance (71 percent), and quality or productivity management (72 percent). What is perhaps most striking in Table 15, however, is that the percentage reporting training varied little (if at all) among engineers working in such disparate engineering activities as applied research, development, design, management, and sales, purchasing, marketing, customer service.

Table 15. Private-for-Profit Sector Engineers Receiving Training, by Main Work Activity, 1997

Main Work Activity	Number of Engineers	Percent with Training
Accounting, finance, contracts	98,700	64
Applied research	181,300	66
Basic research	42,600	64
Computer applications	480,700	65
Development	323,500	67
Design	531,900	65
Employee relations	79,000	72
Managing and supervising	502,400	68
Production, operations, maintenance	88,000	71
Professional services	72,300	60
Sales, purchasing, marketing, customer service	183,900	65
Quality or productivity management	157,900	72
Teaching	16,600	63
Other	66,700	64
Total	**2,825,500[1]**	**66**

NOTE: [1]Post-survey studies (Lessard and Bushery) showed low reliability in distinguishing between primary and secondary work activities; respondents often switched them upon reinterview. Thus, both primary and secondary work activities are referred to as "main work activities," and most respondents thus have two of them.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

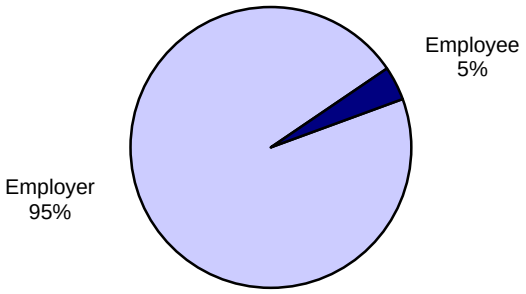
WHO PAYS FOR TRAINING

To determine how much of the training discussed in this report was paid for by the engineers themselves, this report examines the number of days of training received and the proportion of those days paid for by employees. Figure 8, which includes all types of training, shows that the employees paid for only about 5 percent of the total days, indicating that work-related training was overwhelmingly provided by employers. The proportion of days paid for by employees did not vary much by type of training, although it seems to be slightly lower for management or supervisory training, about 4 percent of which was paid for by employees.

[6] There are 14 distinct work activities. Any one which is a person's primary or secondary work activity is defined as a main work activity. Thus, nearly all engineers have two main work activities.

Figure 9 provides information on the average number of days of training received. During the 12-month period ending in 1997, for those who received any kind of work-related training, the average was 10 days of training. Among those who received management training, the average number of days of management training was 6. Those who received occupational training averaged 8 days of it.

Figure 8. Percentage of Days of Training Paid for by Employers Versus Employees in the Private-for-Profit Sector, 1997

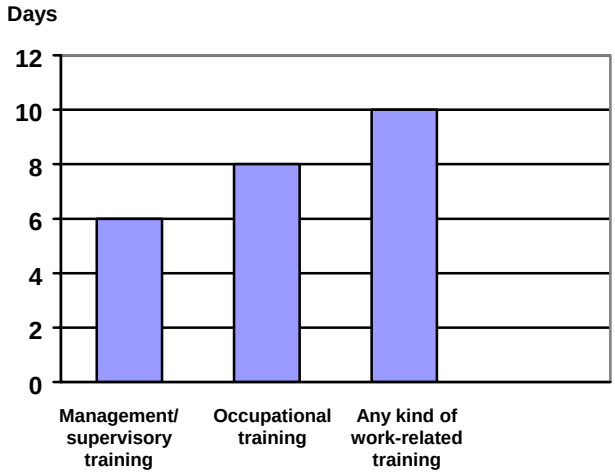


NOTE: Based on restricted sample that excluded the youngest cohorts of engineers, i.e., those who received their bachelor's degrees after the spring of 1990.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

While Figures 8 and 9 provide important insight into the training of engineers, they are subject to a qualification that limits their usefulness. The data for these figures excluded persons who first received their bachelor's degree after the spring of 1990. The situation for all engineers may differ slightly from that of the experienced engineers shown in these figures. For that reason, the remainder of this paper returns to the use of the full NSF SESTAT data set which does not contain such an exclusion.

Figure 9. Mean Days of Training Received by Private-for-Profit Sector Engineers, by Type of Training, 1997



NOTES: Based on restricted sample that excluded the youngest cohorts of engineers, i.e., those who received their bachelor's degrees after the spring of 1990.
Means shown refer only to the kind of training indicated.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

EMPLOYMENT SECTOR

So far this paper has focused on a subset of all engineers—those employed in the private-for-profit sector. The remainder of the paper examines the training for all engineers including both private-for-profit and those employed in other sectors.

As Table 16 indicates, the majority of engineers, regardless of employment sector, reported having received occupational training in 1997, but smaller percentages reported management/supervisory training and general professional training. General professional training includes, for example, public speaking, business writing. While management training was not defined precisely for this study, it is referred to simply as "management or supervisory training," and it probably included training ranging from routine training frequently given to supervisors to expensive seminars offered by top business schools.

As was noted earlier, most engineers worked in the private sector, and they mirrored the total in terms of the percentage receiving training of each type. In contrast, government engineers received more training of every type (except for "other" training), and those in 4-year colleges and universities receive less of every type than do private sector engineers. Table 16 shows an interesting result when state/local government engineers are separated from U.S. government engineers, with state/local government engineers reporting training more frequently than engineers in the U.S. government (82 percent versus 73 percent). This was particularly true in the cases of management training and occupational training.

Table 16. Engineers Receiving Training, by Employment Sector and Type of Training, 1997

Employment Sector	Engineers Employed	Type (by percent): Management/ Supervisory Training	Occupational Training	General Professional Training	Other Training	Percent with Any Kind of Training
2-year college	5,500	16	58	16	2	63
4-year college or university	76,400	8	39	9	6	45
Private-for-profit	1,480,300	24	55	17	6	66
Self-employed	94,700	9	40	8	4	45
State/local government	99,800	43	71	29	6	82
U.S. government	116,200	30	59	20	8	73
Military	18,000	41	65	26	7	75
Other[1]	63,700	24	52	17	6	65
Total	**1,954,600**	**24**	**55**	**17**	**6**	**65**

NOTE: [1]"Other" consists of private not-for-profit organizations and other employers not specifically listed such as foreign governments or international organizations.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Table 16 also indicates that only 45 percent of self-employed engineers reported training in 1997. This is consistent with earlier findings in Figure 3 that the incidence of training declined with employer size. The 45 percent rate for self-employed engineers was similar to the rate reported by engineers in very small firms (under 100 employees).

Table 17 shows the incidence of training by sector of employment and level of highest degree. At both the bachelor's and master's level, the general pattern holds true: government engineers were more likely than those employed in the private firms to report training, while engineers in 4-year colleges and those self-employed reported training less frequently. However, it's also true that in nearly every sector of employment doctoral engineers received training less frequently than engineers whose highest degree was at the bachelor's or master's level. Doctoral engineers in state/local government seem to present an exception to these patterns, but there were relatively few doctorates in this sector.

Table 17. Engineers Receiving Training, by Employment Sector and Degree Level, 1997

Employment Sector	Engineers Employed	Highest Degree Level (by percent): Bachelor's	Master's	Doctorate	Total
2-year college	5,500	s	67	46	63
4-year college	76,400	54	44	37	45
Private-for-profit	1,480,300	66	67	60	66
Self-employed	94,700	45	45	41	45
State/local government	99,800	83	80	82	82
U.S. government	116,200	73	77	59	73
Military	18,000	65	88	57	75
Other[1]	63,600	66	63	54	65
Total	**1,954,600**	**66**	**66**	**53**	**65**

NOTES: [1]"Other" consists of private not-for-profit organizations and other employers not specifically listed such as foreign governments or international organizations.
s = suppressed due to small number of cases.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Table 18 provides more information on how training varied by type of employer. Within the private-for-profit sector, engineers employed by large companies reported training substantially more frequently. However, the differences in training among engineers in the U.S. government and the private sector disappear when one compares U.S. government engineers with those in large companies. In the state and local government sector, the incidence of training did not decrease with size except for governments with fewer than 100 employees.

Table 18. Engineers Receiving Training, by Employment Sector and Size of Employer, 1997
(by percent)

Size of Employer	Private-for-Profit	U.S. Government	State/Local Government	All Other	Total
Over 4,999	74	73	82	56	73
1,000 to 4,999	68	na	83	53	68
100 to 999	60	na	83	63	61
Under 100	50	na	74	45	49
Total, all employers	**66**	**73**	**82**	**52**	**65**

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

State and local governments employ relatively few engineers with doctorates who typically receive training less frequently. However, this does not explain the higher incidence of training among engineers in state and local governments, since at each degree level at least 80 percent of the engineers in state and local governments reported receiving training.

Table 19 shows the proportion of engineers in government employment, and shows this proportion separately for three categories of occupations: those with below-average, near- average, and above-average training incidence. The percentage of engineers employed by state and local government is 22 percent in the specialties with above-average training, but only 7 percent overall. This is an important reason why state and local government engineers reported more training than all engineers.

Table 19. Engineers Employed by Government, by Groups of Engineering Specialties, 1997
(by percent)

	U.S. Government	State and Local Government	Total Government
Engineering specialties:			
with below-average training	11	s	11
with near-average training	6	3	9
with above-average training	8	22	30
Total	**7**	**6**	**13**

NOTES: Specialties with below-average training: aerospace/aeronautical, bioengineers/biomedical, materials/metallurgical, postsecondary engineering faculty, mining/geological/petroleum, and other engineers.
Specialties with near-average training: all other engineering occupations.
Specialties with above-average training: civil, environmental, and industrial engineers.
s = suppressed due to small number of cases.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

OTHER FORMS OF LEARNING

Table 20 shows that, whereas 65 percent of engineers reported training in the past year, 51 percent reported attendance at professional meetings/conferences in the past year, 53 percent were members of a professional society, and 13 percent reported having taken college courses in the past two years. There is some evidence that university-based engineers may substitute these other forms of learning for training; they were more likely to report courses, professional meetings, or professional memberships by a margin that is at least equal to the extent they report training less frequently than other engineers. Engineers in government took college courses and attended professional meetings at rates near the national average for engineers, yet received the most training, so there is no substitution in this sector. Government engineers may have had more explicit expectations to take training than did engineers in other sectors.

Table 20. Engineers with Participation in Training, College Courses, Professional Meetings, and Professional Society Memberships, by Employment Sector, 1997
(by percent)

Employment Sector	Work-Related Training	College Courses[1]	Professional Meetings or Conferences[2]	Professional Society Memberships
4-year college or university	45	39	72	78
Government	77	12	59	55
Private-for-profit	66	13	48	50
Other[3]	55	11	59	58
Total	**65**	**13**	**51**	**53**

NOTES: [1]College courses included any course taken within the past two years.
[2]Professional meetings or conferences included professional society or association meetings or conferences attended during the preceding year only.
[3]"Other" consists of private not-for-profit organizations, the self-employed, two-year colleges, and other employers not specifically listed such as foreign governments or international organizations.

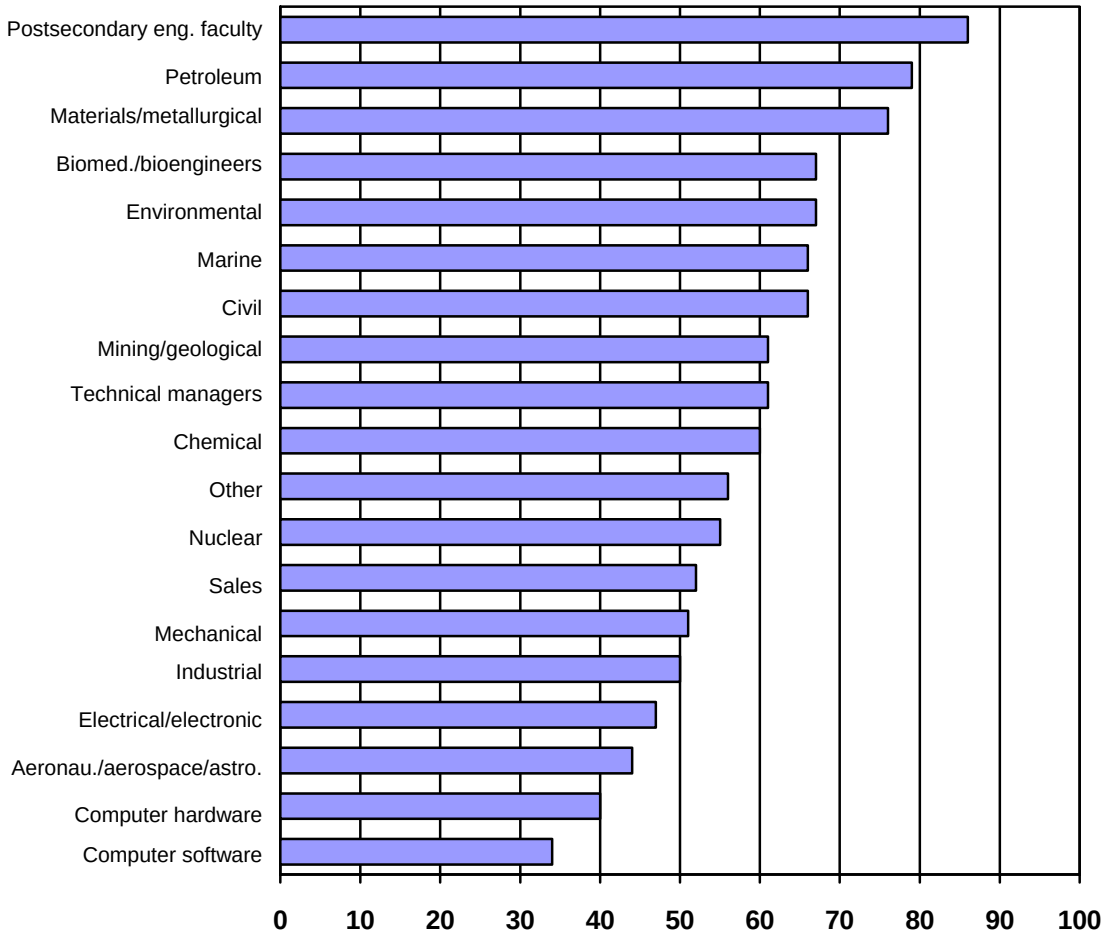
Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Membership in professional societies and attendance at professional meetings are not treated as training activities in this paper. However, since meetings involve technical presentations and membership in professional societies typically includes a subscription to a technical journal, these are important mechanisms that engineers use to keep up with advances in their fields. Figure 10 shows that membership in professional societies varied considerably by engineering specialty. The highest proportion with professional society membership was among postsecondary engineering faculty, and the lowest was among computer engineers (both software and hardware).

TRAINING OF ENGINEERS VERSUS OTHER WORKERS

Studies of training among representative samples of the entire work force in the United States have shown that training is not used primarily to make up for weaknesses in workers' skills. Quite the opposite seems to be the case. Formal training is more common among educated workers. College graduates receive more training than high school graduates, and high school graduates receive more training than dropouts. Within a given industry, workers in high-wage occupations receive more training, on average, than other workers. One interpretation is that the most able workers tend to become the most specialized, and training is one of the mechanisms used to achieve specialized skills. (Neal 1998, pp. 192-193)

Figure 10. Engineers with Memberships in Professional Societies, by Engineering Specialty, 1997
(*by percent)*



Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

Table 21 compares the engineers with college graduates employed in other occupations to provide context for the training of engineers described in this report. The primary reason for reporting 1993 data in Table 21 is that the 1993 National Survey of College Graduates had extensive coverage of people not in science and engineering occupations and permits valid comparisons among occupations.

Technical managers received training at about the same rate as other managers in Table 21. Compared with other college graduates who are non-technical managers, the technical managers received management/supervisor training slightly more often and technical training slightly less often. Overall, the differences between these two groups of managers were remarkably small.

Engineers in Table 21 received training at about the same rate as all other employed college graduates. They received training more frequently than most scientist occupations, perhaps because of the higher concentration of doctorates in the sciences. Engineers also received training more often than engineering technologists and technicians and computer programmers. Computer scientists had training slightly more often, while the fields where licensing and/or certification are very common tended to show a substantially higher proportion receiving training than did engineers.

Engineers reported technical training only slightly more frequently than the other college graduates included in Table 21. While one might think of engineers as being technical professionals more often than other college graduates, Table 21 shows that those in the health professions took technical training even more frequently than engineers. Only one-fourth of the engineers in Table 21 received management training during the preceding year, a fraction that is about the same for all college graduates. However, management training was received most frequently by managers (technical and non-technical). When these are excluded, then engineers reported management/supervisory training substantially more frequently than the other college graduates.

College graduates in occupations which do not usually require a college degree such as the "clerical/administrative" group (45 percent) and "other, blue collar occupations" (47 percent) reported the lowest incidence of training.

Table 21. Engineers and Other College Graduates Reporting Training During the Previous Year, by Specialty and Type of Training, 1993

Specialty	Total Population	(by percent) Management/ Supervisory Training	Technical Training	Any Training
Engineers & technical managers[1]	**1,775,400**	**30**	**56**	**70**
Technical managers	**308,000**	**51**	**47**	**73**
Engineers (exc. technical managers)	**1,467,400**	**25**	**57**	**69**
Computer/information scientists	685,800	23	65	73
Mathematical scientists	89,000	15	50	63
Biological/life scientists	321,400	17	52	65
Physical scientists	279,800	16	47	61
Social scientists	328,400	11	53	73
Managers (non-technical)	5,631,600	47	51	75
Physicians, dentists, psychiatrists & related	807,500	18	66	79
Registered nurses, pharmacists & related	1,033,500	24	72	88
Health technologists and technicians	228,100	17	67	75
Other health occupations	164,900	21	54	72
Presecondary teachers	1,616,500	9	54	83
Secondary teachers	1,690,600	13	56	80
Postsecondary teachers, except science & eng.	511,700	14	42	64
Counselors and social workers	620,100	24	64	90
Clergy	294,200	29	46	81
Engineering technologists & technicians	149,500	16	54	63
Computer programmers	282,700	12	58	64
Sales/marketing	2,421,900	21	49	65
Artists,editors	644,300	10	33	49
Clerical/administrative	1,088,600	10	32	45
Architects	131,500	18	48	59
Farmers, foresters	127,700	18	52	63
Lawyers/judges	771,900	10	66	86
Librarians	159,200	24	61	78
Other, service occupations	683,900	19	43	59
Other, blue collar occupations	638,600	13	38	47
All other occupations	623,200	17	43	59
Total in labor force	**25,576,800**	**25**	**53**	**71**

NOTE: [1]Includes persons who identify their specialty as management-related, whose last degree was an engineering degree and who stated that *either* their work was closely or somewhat related to the last degree, *or* the work required at least a baccalaureate in the natural sciences or engineering.

Source: National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, Division of Science Resources Studies, Scientists and Engineers Statistical Data System (SESTAT).

CONCLUSION

Work-related training is a common occurrence for all types of engineers in a variety of settings. Nearly two-thirds of engineers in the private-for-profit sector received training in 1997. Engineers with doctorates received training less frequently than others, as did engineers in small companies and engineers approaching retirement. The main message of the data presented here is that there are only minor variations in training by age, gender, degree field, degree level, main work activity, and employer's main business.

The findings presented here are consistent with previous research on training and with training in the broader economy. The incidence of training among engineers is quite similar to that of college-educated workers in other fields.

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